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ABSTRACT

This paper reports action research that focuses on gender as a social influence on learning through literacies such as listening, speaking, reading and writing, and orality. Data were collected in three physics classes taught by two teachers, one male and one female, representing three levels of physics. Teachers and researchers worked together in formulating related questions for study, developing questionnaires, and reacting to and analyzing data. The data from the two years of observation in secondary science classes suggest that: (1) behaviors that characterize gender disparity in science include those previously identified in the literature; (2) students are well aware of gender bias in their classrooms; (3) learning in science is influenced by the perceptions and expectations of both teachers and students; (4) gender disparity will be difficult to change; and (5) putting students in small groups does not increase their participation. Contains 48 references. (DDR)

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Texts and Talk: The Role of Gender in Learning Physics

by

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Texts and Talk:
The Role of Gender in Learning Physics

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Prior research in content reading has investigated discussion in classrooms, treating students' discourse about the concepts in texts as literacy (e.g., Alvermann, Dillon & O'Brien, 1987). Content reading and literacy methods textbooks include discussion as a literacy activity designed to promote students' understanding of concepts in texts, build knowledge, clarify ideas, explore issues, and share perspectives (Alvermann & Phelps, 1998; Anders & Guzzetti, 1996; Vacca & Vacca, 1996). In content areas, treating discussion as literacy is based on Gee's (1990) notion that learning to talk the talk of a discipline is part of becoming literate in a field.

Past investigators of discussion in classrooms have identified the types of discussion that occur (Alvermann, Dillon & O'Brien, 1987), and the ways in which teachers can facilitate and guide discussion (Kindsvatter, Wilen & Ishler, 1991). Recently, investigators have turned their attention to exploring imbalances of power and gender bias in classroom discussions of literature (Alvermann & Commeyras, 1994) and discussions of content reading methods (Alvermann, Commeyras, Young, Randall, & Hinson, 1997). Krockover and Shepardson (1995) have requested investigators to turn their attention to science classrooms to identify how students are oppressed in scientific literacy. Such

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studies are needed because males have typically out performed females in science classes and have maintained better attitudes toward science (Kahle & Lakes, 1983; AAUW, 1992).

One reason typically cited for this disparity is differential opportunity to engage in academic tasks and talk about those tasks, commonly referred to as gender bias in science classrooms (NBC News Dateline, Failing in Fairness; Tobin & Garnett, 1987). Within the past decade, researchers have identified behaviors that characterize gender bias in classrooms (Sadker & Sadker, 1994). For example, Morse and Handley (1985) found that teachers allow males to dominate science talk, whatever the structure or activity. A student's argument is taken more seriously by the teacher if the position is asserted by a male (Lemke, 1990). Males receive more attention from teachers than do females, and tend to call out answers in whole-class discussions (Sadker & Sadker, 1994).

Investigations into gender inequities have had several limitations. First, most investigations were conducted primarily by recording percentage tallies in categories on pre-determined observation guides, and have focused primarily on teachers' behaviors. These studies have resulted in the common finding that teachers typically are unaware of gender bias, both in their interactions with students, and in their methods of instruction (Sadker & Sadker, 1994; Tobin, 1988). Hence, researchers have tended to make suggestions for raising teachers' awareness, and for changing teachers' behavior, particularly teachers' talk.

Typical recommendations to teachers have included calling more frequently on females to answer questions, asking them more higher-order questions, and giving more elaborate feedback to females about their responses (Tobin & Garnett, 1987). Others have suggested or tried all-girls classes in science (Kumagai, 1995; NBC News Dateline, Failing in Fairness).

Second, most research on gender and literacy has not considered culture or ethnicity as influences on the development of literacies (Orellana, 1995). While the well-accepted finding (in both the popular press and in academic literature) has been that males dominate classroom interaction (Tannen, 1992) studies like these were criticized for their assumptive nature. Findings from these studies have been generalized from European American, middle-class students to students of other cultures, races, and socioeconomic levels (Orellana, 1995; Swann, 1988).

Recent investigations have shown, however, that other influences, like ethnicity, do interact with gender and impact students' instructional interactions. For example, contrary to findings from studies of European-American females, there is evidence that African-American females often dominant whole-class discussions in science (Luster, Varelas, Wenzel & Liao, 1997) and in other content areas, as well (Kyle, 1996). Mitigating influences (generally referred to as context), like a person's age and generation (Gritsavage, 1997; 1997) or geography (Guzzetti, 1997) can also impact the content and delivery of class members' talk.

Third, few investigators have focused primarily on the interactions between students that constitute gender bias. There have been few studies describing how students in their dealings with each other (and with their teachers) allow, promote, and reinforce gender inequities in the science classroom (Jones & Wheatly, 1991). In addition, few researchers extended their studies of teachers' gendered language beyond quantitative tallies of verbal behaviors (e.g., percentage counts of call outs, questions, and responses by gender) to actually identify the language patterns that disenfranchise students or describe the conditions that allow gender inequities to prevail. Hence, researchers like Alvermann and Commeyras (1994) have called for research that reveals the asymmetrical power relationships between males and females that perpetuate inequities.

Finally, few researchers have attempted to intervene by raising students' awareness or by changing students' behavior that characterizes asymmetrical opportunity and differential power relationships (Tobin, 1988). When these attempts have occurred, they have usually been limited to one-time interventions, like sharing with students the results of research on gender inequities in classrooms (e.g., Sadker & Sadker, 1994).

To expand these investigations and interventions, the studies my colleagues and I conducted (as co-researchers with the teachers in whose classrooms we worked) focused on students' learning. We explored gender disparity in science literacies (i.e., talking the talk of a discipline, using that language to

construct and represent understandings, and acquiring vocabulary or concepts through text and talk about text). In doing so, we focused on students' perspectives and interactions with each other, as well as with their teachers. Although most of the students we studied were European American, we did identify and consider the ethnicities of all the student informants.

In addition, we attempted to change patterns of asymmetrical power relations among students and between students and their teacher in several unique ways. First, we conducted our investigations by recording and analyzing the gendered language patterns and behaviors we observed among students, as well as between teachers and students. Second, we asked our informants to talk with us about their talk in classrooms. Third, we changed grouping patterns for instruction, provided more opportunity for females in whole-class activity, and gave our student informants feedback about their interactions. These methods constituted the action research component of each year's study.

Hence, our descriptive and action research consisted of studying students from two different academic years at three levels of physical science. In the first year, we described teachers' and students' behaviors that perpetuated gender inequities in Physical World, a basic class for non-college bound freshmen, Physics, and Honors Physics. Students in physical science classrooms were chosen for study because physical science is traditionally viewed as a man's field, more so than earth or life science (Kahle & Lakes, 1983). Males have been shown to have

higher self-efficacy in physical science than do females (Smist, Archambault & Owen, 1997).

Most of our first and second years were devoted to describing gendered behaviors and documenting why and how these patterns existed. A portion of each of these years also consisted of action research in which we explored ways to address gender bias. Two of the questions that guided these inquiries were: What behaviors and language patterns do teachers and students display that create and maintain asymmetrical participation in learning science? And, what can teachers do to address gender bias that occurs among students and between students and the teacher?

Theories that Framed our Work

Several cross-disciplinary perspectives guided the focus, data collection, and data analysis. The first of these was social constructivism. From this theory, the learning process is influenced not only by students' prior ideas, but also by the context in which students find themselves and their ideas, and by their interactions within that context. Vygotsky (1978) cites the importance of interplay between language and action as students learn in social settings, like classrooms. Activities like open-ended questions, students' explanations, writings, and classroom dialogue involve interactive and reciprocal use of language to both construct and represent understanding. Students' understandings evolve through a meaning-negotiation process in which they discuss and test their own and others' ideas through

talk. Hence, we turned our focus to language, and how instructional discourse might be influenced by gender.

A second theoretical perspective that influenced these investigations came from socio-linguistics. Given the influence of language on learning from social constructivism, the literature from socio-linguistics that examined gendered forms of language became relevant. Researchers like Edelsky (1981), Tannen (1992) and Tromel-Plotz (1985) have identified language patterns (like interruptions, call outs and loud vocalizations) that characterize asymmetry in opportunity to participate in discussions. These descriptions assisted us in focusing our observations and expanding extant characterizations of instructional interactions that marginalized either gender.

A third theoretical orientation that framed these studies was taken from a typology of feminist theory, since there is no single feminist theory, but rather multiple points of view within feminism (Alcoff, 1989; Stanley & Wise, 1993). The views of feminism conveyed in the studies reflect our personal views. This position may be best described as social feminism (Stanley & Wise, 1993) which emphasizes that "women can't do it all alone" (p. 53), i.e., that men must also be involved in recognizing and addressing asymmetrical power relations that marginalize one gender or another. Hence, we looked for expanded notions of masculinity (e.g., how males can learn and be valued for active listening, which females are typically known for [Dubois & Crouch, 1975; Edelsky, 1979]). From this framework, these studies

identify how males are also disenfranchised when gendered discourse occurs in science classrooms.

Our Procedures of Investigation

Harding (1987) distinguishes methodology from methods by defining methods as techniques for gathering empirical evidence, and methodology as a theory of knowledge or as an interpretative framework that guides a study. Another view of feminism that framed the methodology (and shaped the methods of the studies) was feminist post-structuralism (Lather, 1992). This orientation embraces qualitative research as critical inquiry, a method more amenable to challenging the power and structure of privilege (Giroux, 1992) to change and understand the world (Fay, 1987).

The types of qualitative research that these studies exemplify are case study, the complete study of a bounded and integrated system (Stake, 1994) and naturalistic inquiry. The first investigation, conducted with the male teacher over nearly the complete cycle of the school year, was a case study. The follow-up investigation which spanned a four-month period of the next academic year was naturalistic. Both studies, however, were characterized by data triangulated through direct observations captured in field notes, formal and informal interviews, audio-recorded and videotaped lessons, photographs, questionnaires, and documents like lesson plans, seating charts and worksheets.

These investigations focused on gender as a social influence on learning through literacies (i.e., listening, speaking, reading and writing, but primarily orality. During the first

year, data were collected in three physics classes taught by two teachers (one male and one female) representing three levels of physics (Physical Science or Physical World, Physics, and Honors Physics). These teachers were selected purposively, on the basis of their reputations as effective teachers (as evidenced by their teaching awards), and their willingness to be co-researchers by assisting in formulating related questions for study, developing questionnaires, and reacting to and analyzing data.

Observations occurred daily in the European American male teacher's (Mr. William's) Physics and Honors Physics from the first day of school in August until the end of the third quarter in April. Students in these classes were generally alike in their ethnicity (85% European American, 9% Asian, 4% Hispanic and 2% Native American, with 16% foreign-born). chronological age (juniors and seniors, age 15-17), and socioeconomic status (upper-middle to middle-upper class). The Physics section consisted of two-thirds males and one-third females, while Honors Physics was about evenly divided between males and females. There was essentially no difference between the sections as students could be placed into Honors Physics simply by parent request and many who would have taken Honors Physics were enrolled in the regular section due to scheduling conflicts. Hence, the teacher's lesson plans were essentially the same for both sections.

Observations of the European American female teacher's (Miss Smitt's) Physical World class occurred daily from the first day of school in August until February of that academic year.

Observations of this class ceased when the teacher's absences due to illness became so frequent and long in duration that a realistic picture of her students' interactions and her instruction could no longer be captured. Although enrollment and attendance fluctuated, the 25 Freshmen in Physical World enrolled the first day of school were about evenly divided between minorities and European Americans. Ethnic composition of the class was 44% European American, 32% Hispanic, 12% Native American, and 4% African American, with 56% male and 44% female students. Of the female students, 55% were Hispanic, 12% were Native American, 6% were Asian, and 6% were African American. These students generally represented upper-lower to lower-middle class socioeconomic levels.

The second year's study was conducted with two sections of the male teacher's Physics students, and one section of his Honors Physics students. These sections were evenly divided by gender, and were comprised of approximately the same percentage of ethnic groups as the prior year's classes. Observations of the three sections occurred daily for five months.

All qualitative data, including video and audio recordings of interviews and class sessions as well as field notes, lesson plans, questionnaire responses and journal entries were transcribed to written record. Data were analyzed for patterns through constant comparison (Glaser & Strauss, 1967), and by discrepant case analysis. Member checks were conducted with

informants (teachers and students) through their readings of and reactions to the data to ensure ecological validity.

How Gendered Language is Evidenced in Classrooms: Interactions Between Teacher and Students

We found the same teacher/student interactions in science class previously identified in the literature from studies of other content areas that give males more opportunity to participate in classroom instruction. In Physical World, these behaviors included males shouting out answers, asking immediate questions after the teacher paused, dominating whole-class discussions, and interrupting. Males also tended to hold the floor by illustrating their points or refuting.

Perusal of our observation notes from Physical World showed that in addition to allowing males to dominate the class, the teacher permitted the same boys each day to control whole-class discussions. The teacher reinforced particular male students' participation (Rufus, an African American male, Julio, a Hispanic male, and Byran, a European American male) by elaborating on and validating their remarks, by complementing these boys on their questions and responses, and by showing the class the projects they did as examples to illustrate her lecture. This pattern was illustrated in a lecture/discussion on mechanical advantage:

> Miss Smitts: We've been talking about mechanical advantage.
>
> Observation: A European American male student [Tom] asks the researcher what an inclined plane is used for.
>
> Miss Smitts: You want a truck with a ramp. Why?

Boys, including Julio: So you don't have to pick it up.

Miss Smitts: Work is force times the distance moved.

Byran: In the back of the truck, the door that opens is a pulley.

Miss Smitts: Your car door opens and shuts on a lever. What's your light switch?

Julio: What about your remote?

Miss Smitts: Maybe the mechanisms inside it would. I saw a NOVA presentation on Channel 8. How they were pulling pyramids. All they used were levers and wedges. They didn't have a pulley. Imagine those stone blocks. How did they get those blocks way up high?

Julio: How about the wheel?

Miss Smitts: You know, I saw them trying to use logs, but I'm not sure. It wasn't like the wheel and axle principle. But just imagine those stone blocks of the pyramid...

Julio: They were perfect. They said that the experiment was so geometrically perfect.

Byran: And they tried to put them on logs and roll them. Yeah, they were trying all different kinds of things. They said that back in those days they didn't have a pulley. They didn't use pulleys so all they used were wedges and levers and ropes to pull.

Miss Smitts: They did it with precision to get it perfectly square, like Julio said. I was told they're not off more than 1/4 inch if you measure. That's amazing!

Rufus: Didn't it take them 100 years to build it?

Miss Smitts: No. I think it took about 30 years to build one of the pyramids. But think about how many people were working on that...[Miss Smitts continues her lecture].

Rufus: [interrupting] I have a book on the Nile.

Byran: If it took 30 years for the pyramids to be built, it must have started when the king was born.

Miss Smitts: King Tut? They would start building monuments right away with all kinds of gold inside. You can spot all the simple machines in everyday life.

Julio: There's an ancient mine with doors. On certain days light would shine through the doors.

Miss Smitts: That's right. Stonehenge was like an astronomical clock. People could tell when to plant, when winter would come. Part of the difficulty in making a machine is coming up with the idea. The hardest part is to get started. To come up with the idea and then once you start to work out all the bugs when things go wrong. That's why I wanted you to start with this. Jerry had the ultimate killing machine. I can't get over how your machines mutilated things. Where's the gerbil? [The teacher begins showing poster drawings of the male students' machines that included a live gerbil as part of the machine]. In all of them, everyone wanted to kill this little guy. Everyone somehow either ground him, mutilated him, dismembered him,

took his head off and put it some place else. Whichever way it comes out, I think he's done.

Julio: Mine made money. [student refers to his project].

Miss Smitts: I noticed a lot of you made machines that dismembered the rat that was operating the machine. You used a pulley...

Rufus: The longer it is, the more force you have. The fulcrum is like when you take a screw driver to get a wheel off. What part is the fulcrum?

Julio: [asks a balance question - - inaudible phrasing].

Miss Smitts: What part is the fulcrum? Look up here...

Rufus: I thought that the fulcrum on a teeter-totter was the end where the pressure is.

Miss Smitts: Write this down for 2A. [note taking directions]. The second one is the moveable pulley. That's called the block and tackle.

Julio: I mean one where they were ...[inaudible].

Observation: The class ends with a video that ties machines to force. Three girls of mixed ethnicities at the table next to me draw during the video.

While the males in general (and in this scenario specifically) can be characterized as active, the females in Physical World were generally passive. As this vignette shows, only rarely did females speak in class discussions. Usually, the girls would draw, talk among themselves, or put their heads down and go to sleep during lectures. The girls would wake up when it

was time to do seat work. Typically, when a female did speak in these situations, it was only in response to the teacher's query. Females were not observed asking questions or initiating a topic in whole-class discussion. Males, however, were consistently recognized for their participation. Boys received repetition of and praise or elaboration on their responses and questions.

Data like these from our repeated observations in Physical World indicate the ways in which teachers sustain and promote gender bias in science classrooms. Although, like these students, males may have more favorable attitudes toward physics, no deliberate efforts were made to develop females' interests and curiosities. At this level of physics, the female teacher, as well as her students, perpetuated gender bias in the science classroom.

Gendered Language in Classrooms: Interactions Among Students

Findings from the first year's investigation provided evidence that despite a teacher's intentions to be gender fair, the culture of the classroom may subvert or override these attempts. The male Physics teacher thought he was being equitable in his Physics and Honors Physics classes by calling on proportional numbers of males and females, and by appointing females as discussion leaders. Despite these interventions, debate-like formats favored males, and males dominated activity and talk about that activity in whole class and small-group interactions.

The debate-like format that Mr. Williams used in his whole class discussions was a form of refutational discussion he called

Inquiry Training. Mr. Williams would chose a counter-intuitive concept and pose a question about it. He would then secretly select a member of the class to be a "shill" - - someone who would supply the scientifically unacceptable but logical answer along with a seemingly plausible explanation. If shills could convince others to their way of thinking, they received double points for extra credit, creating a competitive environment. Field notes show that as Tannen (1992) has found, debate-like formats in whole-class discussion favor males. In a typical instance, only a male would assert his opinion and argue for it. In this case, a European American male student was able to persuade the majority of the class to his position:

> Physics Observation, 1/24, 10:10 a.m., Inquiry Training
>
> Mr. Williams: I'm going to start the fan up and the fan will go as fast as it can. Note the direction it's going. [Mr. Williams turns out the lights and turns on the strobe].
>
> Mr. Williams: I'll stop the fan blade and start turning the frequency higher and higher. Will the fan blade turn clockwise or counter-clockwise or will it still look like it's stopped? Let's discuss it.
>
> Evan: It will go clockwise because it is already going in that direction.
>
> Mark: Counter-clockwise!
>
> Mr. Williams: If no one knows for sure, then your comments are just as valid. That's what we do in science. We sift out ideas and find those that are valid.

Mark: It's counter-clockwise. When you're driving on the freeway, it looks like the tires are going backwards even though they really are going forward.

Mr. Williams: What does it look like to you? I'll take the majority answer.

[Mr. Williams asks for a show of hands in response to the three choices. Most students vote for counter-clockwise].

Mr. Williams: I won't tell who the shill is!

Observation: Several boys seated near me ask me for the answer. I decline to participate.

Aside from instances like these in refutational discussion, the teacher also noticed asymmetrical participation in other whole-class discussions. Mr Williams also noted (in a formal interview) gender disparity in activity where small groups report to the whole class, using posters to illustrate their explanations of their solutions to a physics problem, an activity he called Wells Boards:

"I think the girls are a lot less likely to argue with me. I think if we get arguments, it's usually the boys arguing. The girls feel, it seems like to me, when I have them doing Wells boards, a lot more like letting the boy explain everything. They like to sort of hide behind the board or stand back, especially with the math concepts. They seem to shy away from it."

In the past, Mr. Williams had used the seating chart to select the student who would explain the group's Wells board

solution to the whole class. We agreed during this interview that the next time he did Wells boards, he would allow the groups to pick their own spokes person. We would observe together to see if the groups would consistently choose males from their members to explain the concepts to the class. Transcription of this videotaped observation reveals this pattern: [students are European American]

Mr. Williams: Get in your teams, and I'll assign you to Wells Boards. You pick this time who will speak for your group.

Observation: Marcey tells her group she's not doing it.

Marcey: [Talking to Oz, whose father is a physicist] You're the only one in here that knows what's going on.

Ellen: We like you, Oz!

Oz: Would you like some Starburst? [Oz offers candy to the group members and they each accept].

Observation: Bernice presents for her group.

Connie presents for her group. Her group chose Connie because she's a strong speaker, according to one boy in the group.

Mr. Williams: Oz, are you the presenter for that group?

OZ: Yeah. [Oz presents for his group].

Mr. Williams: Shannon, are you the presenter for that side?

Shannon: Yeah.

Mr. Williams: O.K., Shannon, you talk about E for us.

Observation: [Shannon discusses his group's solution].

Mr. Williams: Let's have groups for 2 a and 2 b. Steve, who's responsible in your group? [Group was split between Sam and Brian]. In case of a split, make it Brian.

Mr. Williams: Mike, explain B to us.

Observation: Jon reports for his group. No disagreements or questions.

Mr. Williams: Dean, do you agree? I can't see the numbers on yours.

Dean: The main number is here. [Dean explains his group's solution].

Observation: Groups finish their presentations. Bernice tells me later that their group actually had chosen Phil for the presentation, but Mr. Williams called on her. This means that Connie was the only girl appointed by a group to do the talking in front of the class.

Since females are reluctant to actively participate in whole-class discussions, researchers like Tannen (1992) have recommended that teachers use small groups for discussion. Hence, we were interested to note if females' participation would increase in a small-group activity and talk about that activity, like a lab experiment. Contrary to expectations from the literature, however, females, when placed in small groups with males, did not talk more than they did in whole-class discussions. Girls' roles in these groups were generally confined to recording and reading aloud the data the boys supplied from their set ups, manipulations, and observations. This pattern was

evidenced by an observation of a lab group composed of European Ameircan students, Ericka, Kurt, and Sam conducting an experiment on friction:

Ericka: O.K., What do we do?

Sam: Let's do a nice list of our surfaces.

Sam: Foaming carton, egg carton, plastic bag...[Sam states the items aloud; Ericka records what he says].

Sam: [to Ericka] You scribe today.

Kurt: One half Newton. [Kurt is observing results of pulling the garbage bag on the weight].

Sam: [to Ericka] I guess I'd put the towel down [on the list]. I am so tired!

Ericka: Why?

Sam: I was up til one o'clock last night.

Ericka: The smart one's tired.

Observation: The towel is now placed on the board. Kurt pulls it across the board, and Sam makes a verbalized observation.

Ericka: [Speaking to the researcher] Sam wants to be a physics teacher.

Researcher: Sam wants to be a physics teacher?

Ericka: Yes, he does.

Researcher: [Speaking to Sam] Really?

Sam: Yeah.

Researcher: So you let him do it? You let him make the observations?

Ericka: yeah.

Researcher: [to Ericka] And you act as secretary?

Ericka: Uh huh.

Researcher: And Kurt does the manipulating?

Ericka: Yeah.

Sam: [directing Ericka] When you write bubble wrap, be sure to write bumpy side.

Researcher: Who's not here [today in the group]?

Ericka: Jenna

Researcher: So, she's in your group?

Observation: Ericka nods affirmatively.

Researcher: Is Jenna smart. too?

Kurt: No.

Researcher: No, Kurt? You said no. Why?

Kurt: She whines too much about her opinion.

Ericka: Sometimes she's right, though.

Sam: She got us 10 points extra credit on one lab.

Researcher: So, does she disagree with you a lot?

Ericka: She's skeptical, but not overly skeptical.

It is interesting to note that the one female who did voice her opinions and debate ideas with the males in this group was regarded by a male in her group as whinny. Again, these patterns of females' nonparticipation in small groups of mixed gender were also observed by the teacher, as noted in a formal interview:

"I found out sometimes the best thing I can do as far as lab assignments, and that's what I'm doing on the last one to a

large extent, is to split the girls together, and see if I can put them together. When there's any boys on the team, they defer to the boys, and let them set up equipment, and do stuff like that. Whereas if we have all the girls working together, they seem like hey, no problem. They go ahead and do it [on their own]."

Data like these have shown us that simply putting students into small groups for instruction does not solve the problem of asymmetrical power relations that lead to differential opportunity for participation. At all levels of physics, with both sexes of teachers, in either small group or whole-class activity and discussion, female students played a much more passive role than males did in learning science. These stereotypical roles were reinforced by some of their textbooks which predominately showed photos and illustrations of males engaged in active roles that demonstrated physics principles.

Why Gendered Language is Maintained in Classrooms:

- Perceptions and Expectations

After observing lesson after lesson with these types of interaction patterns, we were able to document how gendered language is constructed in classrooms. My colleagues and I then explored why these norms were allowed to exist. In doing so, we questioned the teachers and their students about their perceptions of gender differences in academic performance or attitudes toward science.

It became apparent that expectations and perceptions on the part of the teachers and/or the students in their classes fostered stereotypical and marginalizing behaviors. In the Physical World class, we found that both the teacher's and the students' assumptions about female students were framed in one of two ways - - either by their preconceptions of females' roles in society, or by their perceptions of the female students' own role expectations for themselves. In the case of the Physical World teacher, her assumptions about the position of a female within a particular culture also framed her expectations, as revealed during a formal interview:

> Researcher: Have you noticed in the interactions of students any gender differences in your classroom?
>
> Miss Smitts: Do you mean ratio wise or what?
>
> Researcher: Not just in terms of numbers, but in any way.
>
> Miss Smitts: Well, like out of a class of 30, I'll have 5 girls.
>
> Researcher: And then, within the numbers, have you noticed any gender differences?
>
> Miss Smitts: I'm not following you.
>
> Researcher: Gender differences in terms of the way they learn or the way they behave.
>
> Miss Smitts: O.K., I see. No. Maybe on a rare occasion I have in the Hispanic girls. Not in their ability to learn, but on their stereotypical attempts to learn. Like if they're paired up with another Hispanic boy, they'll

> culturally believe that it's the boy's place to do certain things. So they leave it up to them without really realizing that they are doing it, and that it's O.K. to be stupid or not do the work because I'm female, and I'm going to have kids and raise a family, and I don't need to know that. But, push come to shove, if I show them that they can do it and encourage them, and because I'm female, I think I see that there really isn't a difference. It's strictly motivation, cultural experience, background.

It is interesting to note in Miss Smitt's response that she reports that only about 15% of her class size is comprised of females, when, in fact, this section was almost one-half females, or 40%. It did seem, however, as if there were fewer females in the class due to their invisibility. Females' lack of presence was evidenced by the absence of their voice in class discussions, their physical seating away from the teacher, their withdrawal from class activity, and, in some cases, by absenteeism. One female Hispanic girl was suspended from school for her truancy. Another female was suffering from Down syndrome and was absent, or when present, never did participate in discussions. Only two or three girls who sat together ever seemed to ask a question in small-group activity or contribute a response in whole-class discussion. These European American and Hispanic girls often put their heads down and went to sleep during lectures and whole-class discussions. These findings are similar to those of Hynd,

et. al. (1994) who studied European American and African-American students also enrolled in a low-level physical science class.

The teacher's role expectations for females alluded to her beliefs about the way in which girls in her class were positioned within their culture and socioeconomic status. Responses from male students, however, alluded not to culture, but more simply to gender. When informed that, from the analysis of our questionnaire data, male students showed better attitudes toward physics than the females in their class did, the boys had ready explanations. These males attributed the nature of their own personalities and their early experiences (which they perceived girls did not typically have) to present attitudes toward physical science. For example, Julio, an Hispanic male, stated, "Boys are more mischievous, and that grows into interest [in science]." Rufus, an African American male stated, "Guys like to mess around and get dirty. Girls don't."

The female Physical World teacher also assigned some of these males' attention-getting behavior to one male's (Rufus') self-consciousness about his cultural difference from the others. Rufus' aggressive behavior was evidenced in several ways, as indicated by observation notes from a Research Assistant:

> Black male student [Rufus] continually interrupts a girl next to him until he is called to the front of the room by Miss Smitts. I didn't hear what she said, but he came back quiet and continued with his experiment without further interruption.

My field notes from an observation read:

> Rob approaches Rufus like a fight will erupt. Miss Smitts physically walks over using her cane. She advises Rob to take a deep breath and count. Miss Smitts tells Rob it is not worth it to get in trouble.

My notes from an informal interview with Miss Smitts cited the teacher's rationale for Rufus' disruptive behavior:

> Miss Smitts and I discussed Rufus' flirtatious behavior. He was done with his questionnaire long before the researcher had finished reading it aloud, and he began to distract the females near him. Miss Smitts felt he did this to be noticed for his behavior, and to avoid being singled out because he's the only Black student in the class. She perceived that it's his way of getting attention for another reason besides being Black.

Although stereotypical, this teacher's beliefs about why students display gendered behaviors in classrooms at least bring to mind the notion of being positioned in multiple ways. Some researchers have pointed out that a person is "multi-layered" (e.g., Weiler, 1988). An individual acts not only from a position of gender, but also from a myriad of other influences as well. Bing and Bergvall (1997) note that:

> "There is considerable evidence that variables such as race, social class, culture, discourse function, and setting are as important as gender and not additive or easily separated" (p. 5).

Students' Gendered Perceptions and Expectations for Each Other

In addition to the comments made by some male students in Physical World regarding role relations, we had a plethora of other evidence that students' perceptions and expectations maintain gendered role relations in science classrooms. Our informants themselves in our first year's study attributed cultural differences to one male's dominance in small-group activity and talk about that activity. Two European Ameircan girls in Honors Physics perceived that a boy in their class had marginalized one of them due to his position as a European-American male raised primarily in a foreign country:

> Observation: Honors Physics, 3/7. Researcher is observing Elaine's lab group. Marcey from another group comes over to Elaine and begins to confide something in her. Marcey appears upset, as she is red in the face, and her voice is stressed.
>
> Marcey: He treats me like I don't know anything knowledge wise.
>
> Researcher: A boy in the group?
>
> Marcey: Umm humm.
>
> Researcher: Does he take over the group?
>
> Marcey: No, not really. There's two people who do all the calculations and controls.
>
> Researcher: Who are the two people in the group?
>
> Marcey: Bill and Oz. Everybody seems to be fine except Oz. This is the first time I've ever felt discriminated against

because I'm a woman. I'm not the only one that thinks that. I thought maybe I was just imagining it, so I was like kind of ignoring it, and I said something to Rob and he agreed.

Researcher: Rob agrees? Is Rob in your group?

Marcey: Yeah. He noticed it, too.

Researcher: So, what does Oz do?

Marcey: Every time I offer to do something, like if I offer to record the data, he has to do it, too. The vibes I get from him is that he has to do it to do it correctly. Something like that.

Researcher: Why do you think he has that attitude?

Marcey: I don't know. But, he doesn't do it with anyone else in the group. So, it makes me feel like he does it with me because I'm a girl. That's what I think.

Elaine: I think I know why he does it. Because Oz is from a different culture. He wasn't raised in the United States. That crossed my mind.

Marcey: Yeah. That crossed my mind, too.

Other data like these, in which students talked about their talk in classrooms were gathered from Physics and Honors Physics during both years. For example, students were given questionnaires assessing their observations of their own and others' participation in discussions and activities. Individuals were asked to identify which student talked the most in class, how willing they were to participate in whole class or small-group discussions, how likely they were to debate a position, and

any differences they saw in how males and females talked in class. In addition, a purposive sample of 22 students in our second year responded to related queries during formal, audio-recorded interviews.

These data revealed in several ways that students of both sexes were well-aware of the forms of gender bias we had identified. First, during both our first and second year's investigation, the majority of males and females in both levels of Physics nominated males as students who talked the most in class. Second, responses to the questionnaire item, "Do you notice any differences in the way boys talk in class versus the way girls talk in class? If so, what?" showed that differential language patterns were observed by both males and females at both levels of physics. In the second year of our study, males in Physics wrote responses like, "Most of the girls seem more timid and shy compared to the boys"; "I think the boys generate ideas faster than the girls; "Boys are more opinionated - - they say what they think"; "Boys are always right"; "Boys make it seem more technical"; and, "The boys are louder and more confident - - they talk more." In Honors Physics, males made comments like, "Boys usually have reasons to back up their hypotheses"; "It's probably not true, but it seems like the boys understand the new concepts more easily"; and "Girls usually ask questions. Boys usually express what they think will happen"; "Girls seem to ask the questions and guys just argue"; and, "Boys are more funny and creative. Girls are more serious and whinny."

Females in Physics during Year Two made remarks like, "The boys talk like they know what they're talking about, whereas girls always seem unsure of their ideas". A National Merit Scholar female in Honors Physics reported, "The girls gibber-jabber and try to talk their way through answers and are more likely to be swayed. [They are] easier to persuade. The boys have more substantive, empirical ways to prove things." Other Honors females' remarks included, "Boys talk without being called on. The girls wait to be called on"; "Guys tend to be hostile - - if you're wrong, you're stupid, according to them. Girls are more likely to listen to an opinion."

Responses from females in the Physics section in Year One (which had the greatest ratio of males to females) focused on intimidation, including remarks from females like, "The boys are loud and obnoxious, and they try to show off, so it intimidates girls from asking questions because they might get made fun of"; "The boys make stupid comments on everything - - the girls keep quiet and to themselves". The males in this section typically self-reported aggressive behavior in discussions, making comments like, "Guys talk more - - they're more outgoing and outspoken"; "Girls say the stupidest things"; and, "The boys are louder."

When confronted with these findings, the males appeared to be proud of their oppressive behavior, while females seemed to be accepting. When the researcher returned to the site at the end of Year One to share these data with the classes, including remarks like, "The boys haven't grown up yet"; "They [the boys] rule the

class", a group of males in Physics broke out in unified song. They sang the Toys R Us jingle which has words alluding the desire to never grow up. Rather than being embarrassed, males celebrated their pride in their oppression of the females.

In response, these females generally agreed that such behavior was to be expected. Females expressed their fears of repercussion in attempting to violate these norms. They spoke of concern for their reputations and their popularity. Even those who had complained to us on an individual basis refused to discuss their observations in a whole-class setting. One female stated, "It just isn't worth it."

How Gendered Language in Classrooms Can Change: Reports of Interventions

Given these conditions, Mr. Williams and I attempted various interventions during the last quarter of our first year's study and the during entire second year. First, students were grouped by sex for small-group activities, like labs. Observations of these interactions showed that when females were grouped with females, groups were characterized by collaborative and equitable participation in activity and talk about that activity.

Interviews with students during same-gender labs revealed that female students appreciated the opportunity to work exclusively together. Two European American females voiced their opinions:

> Roberta: "When I'm with boys, I feel really threatened, like I'm there to collect the data and write it down. The boys

get to do the hands-on stuff. Last semester I had an all-girls group. I prefer it that way. I get to voice my opinions. No one is dominating the group. You don't feel threatened that you will say something stupid.

Tammy: Yeah. [nods her head affirmatively]. I went to an all-girls school before I came here. The learning environment was more relaxed. Then I came here last year and took chemistry. I had 2 girls and 1 boy in my group. He pretty much took over our group."

Although females did participate actively and equitably when placed in same-gender groups like this one, females placed in groups where they were the only one of their gender or where only one of the opposite gender was present again experienced asymmetrical opportunities for instructional activity and discussion of that activity. Because there were uneven numbers of males and females in a class, some lab groups in each section were comprised of mixed genders. In these cases, females often were observed to be or reported being marginalized. And, although we did note females who were more dominant than others in same-sex lab groups, we did not see any female being marginalized in any same-sex lab group.

Despite increased proclivity to talk when placed in small group, single-sex labs, however, females did not become more verbal in whole-class discussions. Girls who did speak in these forums were usually those few who did so prior to our interventions. These girls (all European American) also tended to

be the same female voices heard in each whole-class discussion. Females' increased participation in small-group discussions, whether same or mixed sex groups, did not lead to increased participation in whole-class discussions.

Summary

What have we learned about gender bias from two years of observation in secondary science classes? Findings from these studies can be summarized as follows:

1. Behaviors that characterize gender disparity in science include those previously identified in the literature for other content areas. These include males' interruptions, call outs, and loudness. Females are typically less active in experimentation and discussions.

2. Teachers may not be aware of gender bias in their classrooms, but their students are. Both teachers and students maintain the norms required for its existence.

2. Expectations for and performance in learning science are influenced by the perceptions and expectations of both teachers and students.

3. Gender disparity in classrooms will be difficult to change because of the benefits European American, middle to upper middle class students of both genders receive from maintaining the status quo. Males may continue to enjoy their power and privilege through their superordinate interactions. Females are able to act on their desire for popularity by enacting traditional female roles (e.g., being good listeners and subordinate to males). The

general consensus among students is that gender bias in the classroom is the norm. Attempts to change that norm are either not worth the risk (for females) of popularity or not worth the loss (for males) of power.

4. Simply placing European American and Asian females in small groups does not increase their participation. Placing females in small groups by gender does increase their participation for that event, but does not carry over to whole-class activity.

Implications for Future Research and Practice

Although students in the second year's study were grouped by gender for instructional activity, we realized that same-sex groups are unrealistic in preparing students to work together in the future. For when students do not learn to listen to each other, males who typically do the talking are disenfranchised from acquiring an important educational learning strategy (listening), and do not benefit from hearing the ideas of others. Females are disenfranchised because they do not get opportunities to work through their thinking aloud, or to verbalize questions that would stimulate further thought.

If researchers have failed to counteract gender bias in classrooms, how can teachers do so? Based on my observations of our efforts, and reports of other teacher researchers who have attempted interventions (e.g., Gallas, 1995; Alvermann, Commeyras, Young, Randall & Hinson, 1997), I believe that the key is to involve students. Students must recognize gender disparity as a problem and be active in creating solutions to that problem

within their own contexts. Science education researchers like Tobin (1988) have agreed that teachers should involve students in creating solutions to the problem of gender disparity in science activity and talk about that activity.

How can teachers attempt interventions when they are often blind to the existence of a problem? Teachers can raise their own awareness of gender inequities by observing for the behaviors we have identified, and by designing and administering questionnaires to their students. The questionnaires could be designed like ours with items that ask questions like, "which student talks the most in this class?"; "do you notice any differences in the ways males and females participate in class?" By asking questions like these (through questionnaires or informal interviews with students), and by collecting, tallying, and analyzing these data, teachers can become action researchers in their own classrooms.

If teachers discover gender bias, they may involve their students in interventions that will address their own specific needs. These interventions might include involving students in tracing activity and discussion patterns, critiquing and rewriting texts and materials, writing self-reflections, or monitoring whole-class and small-group discussions. As we did, students might also be involved in developing meta-cognitive awareness of and meta-communication about talk that marginalizes others in classrooms.

What are the implications of this research for future research? Whenever I have talked about these findings with my students or with other researchers, I have been asked the following questions:

1. Would these same patterns of gendered discussion occur in other subject areas, like Social Studies, or in subjects thought of as more feminine, like an English or literature class?
2. What do male/female interaction patterns look like in science classes at various grades (e.g., elementary classrooms) and with different cultures (e.g., primarily Hispanic or African American?
3. How and for how long would the suggested interventions change gendered interaction patterns?

Aside from these queries, in reflecting on the results of these two years of documentation and intervention, I have questions of my own. First, like Alvermann (1993), I am intrigued by the implications of changing gendered patterns of discussion. I am still struck by the resistance on the part of both males and females to confront the problem publicly, despite their complaints to me privately. Will males be willing to relinquish power to gain valuable literacy strategies (i.e., active listening to benefit from females' questions and thought processes)? Will females be able to be less concerned about their reputations and popularity, and become more concerned about their academic opportunity? In what situations are students most likely to make these changes? Finally, like Alvermann (1993), I wonder what repercussions these changes may bring. These are a few of

the questions which I hope that I and other researchers will be able to explore in our future efforts.

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